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Mestrado Integrado em Psicologia

Trabalho efetuado sob a orientação das
Professora Doutora Montserrat Comesaña
Professora Doutora Ana Paula Soares
Professora Doutora Séverine Casalis

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STATEMENT OF INTEGRITY

I hereby declare having conducted this academic work with integrity. I confirm that I have not used plagiarism or any form of undue use of information or falsification of results along the process leading to its elaboration.

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Universidade do Minho, 19/09/2019

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Será que o processamento morfológico em bilingues é modulado por diferenças individuais? Evidência de uma tarefa de decisão lexical de priming mascarado em bilingues Francês-Inglês

RESUMO

Estudos sobre a representação e processamento de palavras morfológicas complexas no léxico do bilingue são escassos e controversos. Enquanto algumas investigações com *priming* mascarado têm observado uma rápida segmentação morfológica de palavras derivadas como *fighter* (*fight* + *er*) tanto na primeira língua como na segunda (para prime-target pares transparentes e opacos; e.g., *fighter-FIGHT* e *wallet-WALL*, respetivamente), outros apenas encontram esta segmentação na língua nativa de bilingues. Estas inconsistências podem ser devido a variáveis lexicais como a *cognatess* (ver Comesaña et al., 2018) assim como a variáveis individuais como os diferentes perfis linguísticos dos participantes (ver Andrews & Lo, 2013). Atendendo a isto, o principal objetivo do presente estudo consistia em examinar o papel das diferenças individuais no processamento de palavras derivadas não cognatas (traduções equivalentes que não partilham a mesma forma, e.g., *blindly*-cegamente). Com este propósito, bilingues do francês-inglês com baixa a intermedia proficiência realizaram uma tarefa de decisão lexical de *priming* mascarado em inglês. Dados provenientes de várias medidas do perfil linguístico foram também recolhidos a fim de determinar o perfil linguístico dos participantes. Resultados obtidos não demonstraram uma rápida segmentação morfológica, suportando assim o modelo procedural/declarativo de Ullman, o qual refere que falantes não nativos não processam informação morfológica de forma rápida e automática tal como acontece com falantes nativos, pelo menos quando os participantes não são proficientes na sua língua não nativa.

Palavras-chave: bilingues, diferenças individuais, palavras derivadas, *priming* mascarado, processamento morfológico

Is bilingual morphological processing modulated by individual differences? Evidence from a masked priming lexical decision task with French-English bilinguals

ABSTRACT

Studies on the way morphologically complex words are represented and processed in the bilingual lexicon are scarce and controversial. While some masked priming investigations have observed an early morphological segmentation of derived words like fighter (fight + er) in both native and non-native languages (for transparent and opaque prime-target pairs; e.g., fighter-FIGHT and wallet-WALL, respectively), others only found this segmentation in the bilinguals' native language. These inconsistencies may be due to lexical variables such as word cognateness (see Comesaña et al., 2018) as well as to individual variables like the different linguistic profiles of participants (see Andrews & Lo, 2013). Taking this into account, the main aim of the present study was to examine the role of individual differences in the processing of non-cognate (equivalent translations that do not share form, like blindly-*cegamente*) derived words. To that purpose, unbalanced French-English bilinguals with low to intermediate English proficiency carried out a masked priming lexical decision task in English. Data from several linguistic profile measures were also collected in other to determine participants' linguistic profile. Results failed to show a fast morphological segmentation given support to Ullman´s procedural/declarative model according to which non-native speakers do not process morphological information in a rapid and automatic way as native speakers do, at least when participants are not too much proficient in their non-native language.

Key-words: bilinguals, complex derived words, individual differences, masked priming, morphological processing

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ABBREVIATIONS AND ACRONYMS

VWR - Visual Word Recognition

ms - Milliseconds

ERPs - Event-Related Potentials

RT -Reaction Time

L1 - First Language

L2 - Second Language

EP - European Portuguese

LHQ - Language History Questionnaire

AoA - Age of Acquisition

M - Mean

SD – Standard Deviation

WIAT-II - Wechsler Individual Achievement Test (2nd ed.)

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Is bilingual morphological processing modulated by individual differences? Evidence from a masked priming lexical decision task with French-English bilinguals

A number of studies have been demonstrating that complex words are fast and automatically decomposed during visual word recognition (VWR), i.e., that complex derived words as 'teacher' are decomposed into its morphemic constituents (base 'teach' + suffix '-er'] before lexical access is reached. In the majority of these studies a lexical decision task (participants are asked to decide whether a chain of letters is a real word or nonword in a given language) combined with a masked priming paradigm is used. This paradigm, which is highly used to tap into the earlier stages of VWR, consists of the presentation of a forward mask, followed by a prime lowercase for around 50 ms, which is then replaced by a target uppercase word (Forster & Foster, 2003). In morphological masked priming studies, primes are typically complex words that can be morphological related or not with the target (e.g., reader-READ vs. issuer-READ). The difference in latency and/or error data between related and unrelated conditions is used to compute the so-called morphological masked priming effect, an index of morphological decomposition at early stages of visual word recognition.

For instance, in a masked priming lexical decision study conducted by Morris, Frank, Grainger and Holcomb (2007) the processing of morphological derived words was examined in a group of native speakers of English. Event-related potentials (ERPs) and behavioural data were collected. The stimuli used were divided in three conditions based on the relation established between primes and targets: (i) transparent condition, in which words were semantically, morphologically and orthographically related (e.g., hunter-HUNT); (ii) opaque condition, in which words were orthographically related and only apparently related in morphology (e.g., corner-CORN); and (iii) orthographic control condition, in which words were exclusively related in orthography (e.g., starch-STAR). Note that the last letters in the opaque condition form a real suffix in the lexicon (-er) whereas in the control condition they do not (-ch). Both, behavioural and ERP data, showed modulations in the masked priming effect as a function of the level of semantic transparency. Specifically, the authors found that the size of the morphological priming effect was higher for words from the transparent condition, intermediate for words from the opaque condition, and smaller for words from the orthographic control condition, although only significant for transparent pairs. These findings are in agreement with the results obtained recently by Marelli, Amenta, Morone and Crepaldi (2013, Experiment 2) with Italian native speakers and also with the results of previous studies (Longtin, Segui & Hallé, 2003, Experiment 1 with French speakers; Rastle, Davis and New, 2004, with British- English speakers), although in these previous studies, morphological priming effects were observed not only for transparent but also for opaque condition.

Overall, these findings demonstrated that the decomposition process occurs fast during the VWR of native languages. Models in which several routes of processing are considered are the most adequate to account for these data (see Grainger & Ziegler, 2011; Kuperman, Schreuder, Bertram, & Baayen, 2009) or even models characterized by flexible architectures and temporary representations which change as a function of task requirements (see for example the model for masked priming by Norris & Kinoshita, 2008). For instance, Grainger and Ziegler (2011) developed a dual-route model in order to explain lexical access, with a fine-grained orthographic processing route, in which occurs a morpho-orthographic segmentation, and a coarse-grained orthographic processing route where occurs a whole-word processing; according to the authors both routes work separately, feeding information in separate channels at the same time in order to activate the correct word. In a similar vein, Kuperman et al. (2009) defend the existence of multiple routes that interact with each other in a maximize and effectively way in order to process complex words using the different information contained in it (e.g., morphological, phonological, contextual, and orthographic information). Additionally, Norris and Kinoshita (2008) argue that the processing of complex words depends on task's requirements, i.e., participants activates the representations needed in order to perform efficiently the current task. Taking in account these different theories, we believe that in the different experimental studies mentioned (i.e., Longtin, Segui, & Hallé, 2003; Marelli et al., 2013; Morris et al., 2007; Rastle et al., 2004), the pathway followed (form-based vs. semantic-based) depended on task requirements (if participants are informed that they need to understand the presented word they will follow a semantic based route, while if they are asked to say if the string of letters they are seeing is a real word or not they will follow a form-based route - see Marelli et al., 2013) and probably task sensitivity (tasks with high temporal resolution are able to better capture the phenomenon under study).

Despite widespread agreement that VWR of native complex words involves a fast decomposition process of word morphemic constituents, evidence with non-native languages is scarce and controversial. The main question in this line of research is to examine if morphological information guides VWR in the non-native or second language (L2) as it does during VWR with native languages (e.g., see Comesaña et al., 2018 for an overview). Whereas some studies showed a similar processing for native and non-native languages (e.g., Diependaele, Duñabeitia, Morris, & Keuleers, 2011; Voga & Anastassiadis-Symeonidis, 2014) others found a dissimilar processing (e.g., Heyer & Clahsen, 2015; Silva & Clahsen, 2008). For instance, Diependaele et al. (2011) used a masked priming lexical decision task with the three typical conditions (transparent, opaque and orthographic control), in order to compare the performance of early Spanish-English bilinguals and late Dutch-English bilinguals with native speakers of English. They found a similar pattern of results in the processing of morphological complex words in the first (L1) and second languages, independently of the age of L2 acquisition. That is, the authors found a linear pattern of priming across the three conditions: a priming effect for the transparent condition, an intermediate significant priming effect for the opaque condition, and a smaller priming effect for the orthographic control condition. Being the priming effects mentioned significative for the three experimental conditions. These results account for the evidence that non-native speakers process complex derived words as native speakers do. Contrary, Heyer and Clahsen (2015) using a similar paradigm, but only with transparent and orthographic control conditions, observed a different pattern of results between late German-English bilinguals and English native speakers. Specifically, the authors found a priming effect for both transparent and orthographic control conditions for bilinguals, and a priming effect only in the transparent condition for monolingual participants, suggesting that non-native speakers, opposing to native speakers, take mainly into account orthographic information during a VWR task, instead of the morphological information present in it. Recent studies with native speakers and bilinguals have been suggesting that these inconsistencies might be due to the influence of variables such as the cognateness of morphemic constituents (i.e., the degree of form similarities across-languages between whole-words, bases and suffixes - see Comesaña et al., 2018 for more detail), as well as the individual differences in terms of linguistic profile (semantic profile vs. orthographic profile - see Andrews & Lo, 2013; slow vs. faster readers - see Medeiros & Duñabeitia, 2016; or high vs. low L2 proficiency - see Li, Taft, & Xu, 2017) .

Regarding the cognateness variable, Comesaña et al. (2018) found that morphological priming effects in late EP-English bilinguals are greater for L2 words containing cognate suffixes (e.g., passage-*passagem*; brokerage-*corretagem*) than for words with non-cognate suffixes (e.g., blindly-*cegamente;* rarely-*raramente*), which could explain some of inconsistencies above mentioned as previous studies did not control for suffix cognateness (see for instance Diependaele et al., 2011). Other studies also showed that morphological processing is also affected by individual differences, although most studies conducted thus far were done with monolinguals. Specifically, in this line of research some studies have been comparing morphological awareness measures (i.e., tasks that assess individual's conscious awareness of the morphemic structure of words and individual's ability to reflect on and manipulate the words' morphological constituents - Carlisle, 1995) to measures of individual differences in terms of spelling, reading and vocabulary. For instance, Fracasso, Bangs, and Binder (2016) compared morphological awareness capacity to spelling, vocabulary, and reading comprehension skills of English native speakers. They observed that morphological awareness was positively correlated to the three individual measures. Furthermore, Wilson-Fowler and Apel (2015) comparing morphological awareness measures to individual differences in spelling, word reading and reading comprehension tasks, also verified a positive correlation between them. More precisely, these authors found out that spelling is better predicted by morphological awareness (59%) than word reading (38%) and reading comprehension (33%).

Based on this evidence, some researchers have been focusing on exploring how individual differences can influence the performance of individuals on morphological masked priming lexical decision tasks. For instance, Andrews and Lo (2013) assessed whether the results on vocabulary and spelling tests of Australian native speakers of English could be modulating participants' performance on a masked priming decision lexical experiment in which the three typical conditions (transparent, opaque and orthographic control) were examined. Specifically, Andrews & Lo (2013) divided the participants in two groups accordingly to vocabulary and spelling scores: the "orthographic profile" group (higher scores on spelling tests than on vocabulary tests) and the "semantic profile" group (higher scores on vocabulary tests than on spelling tests) and analysed the results from a masked priming decision lexical considering these linguistic profiles. Overall, data analyses of reaction times (RT) showed stronger morphological priming effects for the transparent and opaque conditions than for the control condition, as in previous studies with native speakers (e.g., Longtin, Segui, Hallé, et al., 2003; Rastle et al., 2004). More interestingly, participants with an "orthographic profile" showed a stronger and similar significant priming effect in both opaque and transparent conditions, while participants with a "semantic profile" showed a superior priming effect in transparent condition than in opaque conditions. Further analysis of RT distributions allowed the authors to observe a more pronounced pattern of the previous results, i.e., that the "semantic profile" was associated with a significant gradual increase in the priming effect of the transparent and orthographic conditions across RT distribution and a gradual decrease in the priming effect of the remaining condition (opaque); while "orthographic profile" was associated with a significant gradual increased in the priming effect of the opaque condition across RT distribution and a gradual decrease in the priming effect of transparent and orthographic conditions. Additionally, in the analysis of fast responses, in both linguistics profiles, "semantic" and "orthographic", showed stronger priming effects for the morphological conditions (transparent and opaque); however, despite the priming effects for orthographic condition being smaller in both linguistic profiles, it was stronger for the "orthographic profile". These authors referred that these findings go in line with multiple route models (Kuperman et al., 2009), once participants with different linguistic profiles seem to use different lexical routes in order to retrieve more rapidly the word they are reading.

Another individual variable that have been also studied in morphological masked priming lexical decision studies with native speakers is their reading profile. Medeiros and Duñabeitia (2016) applied a masked priming lexical decision task with related and unrelated conditions with derived complex Spanish words to Spanish native speakers dividing participants in two different linguistic profile groups according to their mean RTs: "faster readers" (short RTs mean) and "slower readers" (long RTs mean). Through this procedure, authors were able to observe only a stronger and significant morphological priming effect for the "slower readers". These results suggest that while "slower readers" decomposed complex words in their morphemic constituents, "faster readers" tend to process the whole word and thus no masked morphological priming effects were found.

Regarding L2 proficiency, Li et al. (2017, Experiment 1) compared the performance of English native speakers to Chinese-English bilinguals with different levels of L2 proficiency (high proficient bilinguals vs. low proficient bilinguals) in a masked priming lexical decision task with transparent, opaque and orthographic-control conditions. With this procedure, the authors observed that native speakers and bilinguals with a high level of L2 proficiency showed a similar pattern of results: priming effects for transparent and opaque conditions that did not differentiate between each other, and no priming effect for the orthographic control condition. However, in bilinguals with lower levels of L2 proficiency significant priming effects for transparent and orthographic control conditions were observed, but not for the opaque condition. These outcomes lead the authors to conclude that while high proficient bilinguals seem to apply decomposition rules while reading complex words, as native speakers do, lower proficient bilinguals seem to rely more in the form of the word, not taking in account the morphological information present in the words, suggesting that neither a morpho-semantic processing neither morpho-orthographic processing are being applied by these group of participants. From this investigation with bilingual participants, we can infer that the level of L2 proficiency modulates the way morphological complex words are processed, i.e., the higher the L2 proficiency, the more similar their performance is to that observed with native speakers.

Overall, these studies emphasize the importance of taking into consideration the role of individual differences when evaluating morphological processing, something that despite of their importance for models of bilingual VWR has not been considered in the majority of studies assessing L2 morphological processing (Deng, Shi, Dunlap, Bi, & Chen, 2016; Li et al., 2017; Veríssimo, Heyer, Jacob, & Clahsen, 2018) . This is precisely the aim of the present research: to examine the role of individual differences in terms of vocabulary, spelling, text comprehension and reading rate in the processing of L2 non-cognate words distributed across transparent (e.g., fighter-FIGHT), opaque (e.g., belly-BELL), and orthographic control (e.g., need-NEEDLE) conditions. A masked priming lexical decision experiment with unbalanced late French-English bilinguals (low to intermediate level of L2 proficiency) was used.

Based on the existent literature, we expected to observe morphological masked priming modulations as a function of individual differences. Specifically, if bilinguals decompose complex words as native speakers, we expected to find greater masked priming effects for words with a morphological structure (transparent and opaque conditions) than for words from the orthographic control condition. Differences in the size of priming between transparent and opaque conditions could be expected especially in those participants with better performance in vocabulary than in spelling tasks (i.e., with a semantic profile).

METHOD

Participants

Forty-two French-English intermediate unbalanced bilinguals, with normal or corrected-to-normal vision participated in the experiment. They were undergraduate students from University of Lille (37 women, M_{Age} = 21.71, *SD* = 6.12). Prior to the experiment, participants signed a written informed consent form where a brief explanation of the study was provided, as guaranteed the anonymity of their data. All participants were volunteer and did not receive accreditation or payment to participate in the experiment.

L2 proficiency was evaluated using the *Language History Questionnaire* (LHQ; Li, Zhang, Tsai, & Puls, 2015). This self-reported questionnaire collects background information regarding the L2 such as age of acquisition (AoA), and levels of proficiency in terms of reading, written, speaking and listening (these levels are evaluated through a 7-point Likert scale: from 1= very poor to 7=native-like), which allowed us to characterize our participants as late bilinguals (M_{AoA}= 10.21, *SD* = 1.98), with an intermediate level of L2 proficiency (*M* = 4.35; *SD* = 1.38).

Moreover, several tests were used to assess the linguistic profile of participants. Specifically, we used: (i) the *Nelson-Denny Reading Test* (Brown, Fishco, & Hanna, 1993) to assess vocabulary and reading comprehension skills in English; (ii) the *LexTALE* to assess English vocabulary size (Lemhöfer & Broersma, 2012); and (iii) the spelling test of the *Wechsler Individual Achievement Test (2nd ed.)* (WIAT-II; Wechsler, 2005) to assess English spelling skills. The vocabulary test of *Nelson Denny Reading Test* is composed by 80 items. In each one, participants are asked to match a word to its best definition among the five options that are given. The reading comprehension test consists of a set of seven passages with literal and inferential multiple-choice comprehension questions. The *Nelson-Denny Reading Test* was validated in American native speakers, having been developed norms according to the age and level of education; moreover, this test reliability coefficients range from .85 to .95. Both tests have a time-limit of 15 and 20 minutes respectively. Since we used these tests to evaluate English as an L2, no time limit was given to participants perform the tests, although time participants took to perform them was registered. *LexTALE* is a lexical decision task composed by 60 trials aimed to assess how many L2 words participants know. In each trial participants must decide whether or not a chain of letters displayed corresponds to an English real word. This test has a duration of approximately 5 minutes. A validation study was conducted with non-native speakers of English, having this test a reliability coefficient that ranges from .81 to .68. Finally, the spelling test of WIAT-II consists in a dictation-word task composed by 26 trials. For each trial, a word is readed by the experimenter, then a sentence with the word, afterwards the word is repeated, and finaly the participant writes down the word heard. This test has a duration of 10 minutes. The WIAT-II was validated to a population with ages between 4 and 17, having a reliability coefficient that ranges from .85 to .98. In table 1 are presented the mean scores of participants on the different linguist profiles' tests above mentioned.

Table 1. Mean score and standard deviation (in parenthesis) of participants in each of the linguistic profiles' tests.

	WIAT-II	*Nelson-Denny Reading Test*			*LexTALE*
		Vocabulary	Text Comprehension	Reading Rate	
Mean Score	*36 (4)*	37 (10)	17 (6)	152 (51)	67 (9)

Note. WIAT-II maximum score = 53; Vocabulary part of *Nelson-Denny Reading Test* maximum score = 80; text comprehension part of *Nelson-Denny Reading Test* maximum score = 38.

Materials

Seventy-eight non-cognate English words were selected as targets, which were distributed equally according to three experimental conditions: transparent (i.e., prime and target are semantically, morphologically and orthographically related - e.g., fighter-FIGHT), opaque (i.e., prime and target are orthographically related and apparently related in morphology - e.g., belly-BELL) and orthographic control (i.e., prime and target are only orthographically related- e.g., needle-NEED). Across conditions words were matched in terms of logarithmic (base 10) per million word frequency and word length (number of letters) (all *p*s ≥ .31) as obtained from the *Subtlex-UK database* (Heuven, Mandera, Keuleers, & Brysbaert, 2014). We also guaranteed that there were no differences regarding the French translation of the targets in terms of frequency and length (all *p*s ≥ .21) as obtained from the *Lexique database* (New, 2006).

One hundred and fifty-six English words were additionally selected as primes. These words were selected to be morphologically (e.g., fighter-FIGHT) or orthographically related (e.g., needle-NEED) or unrelated (e.g., fighter-READ) to the target words. Primes were matched across conditions in terms of word frequency and word length (number of letters), as well as on their French equivalent translations (all *p*s ≥ .27). The orthographic overlap between primes and targets across conditions (*Normalized Levenshtein Distance* – NLD) were also controlled for by using the *NIM database* (Guasch, Boada, Ferré, & Sánchez-Casas, 2013) ($p = .80$). Frequency and length values for targets and primes can be seen in the Table 2.

Table 2. Mean and standard deviations (in parenthesis) of logarithmic frequency and length of related and unrelated prime words and target words in each experimental condition.

	Prime				Target	
	Related		Unrelated			
	Logarithmic Frequency	Length	Logarithmic Frequency	Length	Logarithmic Frequency	Length
Transparent	0.81 (0.47)	6.46 (0.63)	0.96 (0.43)	6.62 (1.11)	1.62 (0.67)	4.26 (0.58)
Opaque	0.97 (0.47)	6.32 (0.79)	0.95 (0.30)	6.54 (1.01)	1.33 (0.83)	4.04 (0.73)
Orthographic control	0.85 (0.72)	6.23 (0.56)	1.05 (0.25)	6.46 (0.80)	1.44 (0.70)	4.08 (0.43)

Seventy-eight English pseudowords were also created for the purpose of the lexical decision task. These pseudowords were generated by using the *Wuggy software* (Keuleers & Brysbaert, 2010) based on a new list of words from the same populations as the experimental ones. Additionally, 156 English words were also selected as primes to assign each pseudoword target to the related (e.g., fully-LELL) or an unrelated (e.g., beffy-LELL) conditions. No differences were seen in terms of frequency and word length for these stimuli across the different conditions (all *ps* = .14).

Two list of materials were created to ensure that each target was preceded by a related and an unrelated prime, although in different lists.

Furthermore, 15 words (10 primes and 5 targets) were selected and 5 pseudowords created using the *Wuggy software* (Keuleers & Brysbaert, 2010). These items formed the practice block.

Procedure

The experiment was conducted individually, in a quiet room. Firstly, participants were asked to sign an informed consent and to fill the LHQ (Li et al., 2015). Then they carried out the masked priming lexical decision task, in which they were asked to decide whether a given chain of letters was or not a real English word. Participants were instructed to press the "Right SHIFT" key if they thought that were seeing a real English word or to press "Left SHIFT" key if they thought they were seeing a pseudoword. For each trial, a forward mask was presented at the centre of the screen during 500 ms (######), followed by a lowercase prime word displayed in 12-pt Courier New during 50 ms, and then the presentation of an uppercase target word until participant's response or 3,000 ms have elapsed. At the beginning of the task a practice block was presented with 10 trials (five words + five pseudowords) to familiarize participants with the task, and it was followed by the experimental block composed by 156 trials (78 words + 78 pseudowords). This task was administrated using de *DMDX software* (Forster & Forster, 2003).

After completing the lexical decision task, the tests to assess participants' linguistic profile were administered individually in the same room. Firstly, the spelling test of WIAT-II was administered to avoid any contamination on the subsequent tasks once the words in this task could appear or be similar of the ones presented in the other tests. Then the *Nelson-Denny Reading Test* and the *LexTALE* task were applied. In total the whole session took 90 minutes per participant.

RESULTS

RTs and error data below 250 ms and above 2000 ms were excluded from the analysis. The same happened for RTs data of participants above or below 2.5 standard deviations of the mean RTs of each participant per condition. This led to a removal of 5.46% of original data. None of the 42 participants or items were excluded.

Data descriptive in terms of mean RTs and percentage of errors are present in the tables 1 and 2 respectively.

Table 3. Mean Reaction Times (ms) and respective standard deviations (in parenthesis) in each experimental condition.

	Transparent	Opaque	Orthographic Control
Related	735 (199)	774 (212)	762 (198)
Unrelated	777 (194)	798 (199)	771 (179)
Prime effect	42	24	9

Note: Priming effect corresponds to difference between unrelated and related mean values.

Table 4. Mean percentage of errors (%) and respective standard deviations (in parenthesis) in each experimental condition.

	Transparent	Opaque	Orthographic Control
Related	19.3 (39.5)	17.7 (38.2)	18.7 (39)
Unrelated	20.1 (40.1)	20.5 (40.4)	20.4 (40.3)
Prime Effect	0.8	2.8	1.7

Note: Priming effect corresponds to difference between unrelated and related mean values.

RTs and accuracy of target words were analysed applying a linear mixed models (lme) analysis through the lme4 package of the R program library and LmerTest library in order to contrast simple effects with least squares means differences. For RTs analysis, participants and items were treated as crossed random factors and with random intercept, being that for repeated measures only a random slope per participant was applied. For accuracy analysis, a generalized lme with a logistic link function and binomial variance was conducted.

Linguistic profile differences, namely, spelling, vocabulary, text comprehension and reading rate, were inserted in the analysis as covariables.

There was no averaging of the data previous to the analysis.

RTs analysis showed a main effect of relatedness (F(1, 136.42) = 6.52, $p < .05$), as responses were slower for unrelated than for related pairs. Neither the main effect for target type (F(2, 147.91) = 1.43, p = 0.24) or the interaction between relatedness and target type was significant (F(2, 147.94) = 0.56, p = 0.57). Moreover, no main effect was observed for the covariables spelling (F(1, 39.75) = 0.14, p = 0.70), vocabulary (F(1, 39.71) = 0.77, p = 0.38), text comprehension (F(1, 39.45) = 1.79, p = 0.19), reading rate (F(1, 39.31) = 0.52, p = 0.47) and total score of Nelson Denny Reading Test (F(1, 39.55) = 1.52, p = 0.22).

For accuracy, no main effects of prime type (X^2 = 0.59 (1), p = 0.44 and target type (X^2 = 0.15 (2), p = 0.93) were found. The interaction between prime type and target type also failed to reach significance (X^2 = 0.19 (2), p = 0.91).

DISCUSSION

In this study, we examined if individual differences in terms of spelling, vocabulary, text comprehension, and reading rate modulated morphological priming effects as seen in previous studies with native speakers (Andrews & Lo, 2013; Medeiros & Duñabeitia, 2016). To do that, low to intermediate proficient late French-English bilinguals carried out a masked priming lexical decision task in which three conditions would be distinguished (transparent, opaque and orthographic control). Through this procedure, first of all we expected that our bilingual participants would decompose complex derived words in their morphemic constituents in a rapid and automatic way as native speakers do, as seen in the previous investigations of Diependaele et al. (2011) and Voga & Anastassiadis-Symeonidis (2014). More precisely, we expected a significant and stronger priming effect for both morphological conditions (transparent and opaque) in comparison to the orthographic control condition, specifically if they had a higher score on spelling than vocabulary. Differences in the size of priming between transparent and opaque conditions were also expected especially in those participants with better performance in vocabulary than in spelling tasks (i.e., with a semantic profile).

Contrary to what was hypothesized, the results failed to show: a) morphological priming effects; and b) modulations in masked priming effect as a function of individual differences. Note that we are assuming that English native speakers would show significant morphological priming effects with these materials as was observed in other studies with similar stimuli (e.g., Diependaele et al., 2011; Voga & Anastassiadis-symeonidis, 2014), however a replication of this study with native speakers would be desirable in order to strength this statement.

In fact, the fact that we have failed to observe morphological priming effects (i.e., a difference in the size of priming between morphological conditions [transparent and opaque] and the control condition) seem to indicate that non-native speakers do not process morphological information in a similar fashion of native speakers, at least when the level of L2 proficiency is not too high. This data gives support to what was observed in the previous experimental studies of Heyer & Clahsen (2015) and Silva & Clahsen (2008) with high proficient bilinguals. More specifically, our data analysis showed just an overall masked priming effect which was independent of the type of target. This indicates that participants were not sensitive to the morphological information. Conversely, it seems that they were guided by orthographic information and this is the reason why no differences emerged across conditions (note that three conditions were matched in the degree of orthographic overlap between prime and target). It is worth mention that mean RTs data of each condition showed, however, the expected pattern of results: higher priming effect for the transparent condition, an intermediate one for the opaque conditions, and a smaller priming effect for the form control condition. It is possible that applying the same procedure to more proficient bilinguals would allow us to observe differences statically significant among the different experimental conditions. This should be address in future investigations.

These results, as well the ones observed in Heyer & Clahsen (2015) and Silva & Clahsen (2008) studies, are in line with the declarative/procedural model of Ullman (2002). This model refers that are two types of memory: the declarative memory (or "explicit memory"), which consists in the storage of lexical knowledge, being this retrieved consciously; and the procedural memory (or "implicit memory") , which consists in the grammatical knowledge and is accessed unconsciously. Moreover, Ullman (2002) refers that while native speakers rely more in a procedural memory, processing morphological information in a rapid and automatic way, non-native speakers do not, relying more in the knowledge about the language present in their declarative memory. According to the author, this difference on the processing of this kind of information occurs cause of the later learning of L2, as well the inferior knowledge of non-natives comparative to natives about the language, which does not allow these processes to become automatic, i.e., procedural. Both these factors are present in our bilingual sample, since this is composed by late French-English bilinguals with a low to intermediate English proficiency.

Relatively to the AoA variable, Veríssimo et al. (2018) procured to verify if this, in fact, modulated the priming effect of complex words. In other to examine this, authors applied a masked priming lexical decision task with inflected and derived complex words to Turkish-German high proficient bilinguals, distributed among three experimental conditions (i.e., transparent, opaque and orthographic control conditions), to early and late bilinguals. These authors observed that inflexional priming was modulated by AoA, while derivational priming was not. Based on these results, we can not infer that the late learning of L2, as suggested by Ullman's theory (2002), is an explanation for the results observed in our study, since as seen in the study of Veríssimo et al. (2018), late bilinguals seem to be able to apply the derivational rules in order to decomposed derived complex words in their basic morphemic constituents in a fast and automatic way.

In other hand, other studies (e.g., Deng, Shi, Dunlap, Bi, & Chen, 2016; Li et al., 2017) have been focusing on comparing native speakers' performance on a masked priming lexical decision task to bilinguals with different level of proficiency of L2 (high vs low proficiency), no varying in terms of AoA. Li et al. (2017) applied the mentioned paradigm with three different conditions (transparent, opaque and orthographic control), and verified that while both native speakers and high proficient bilinguals presented significant priming effects for both morphological conditions (transparent and opaque), low bilinguals showed significant priming effects for transparent and orthographic control conditions. This led the authors to conclude that while participants with higher proficiency of L2 and native speakers seem to process morphological information in a same manner, participants with lower proficiency of L2 do not. Similar conclusions were obtained by Deng et al. (2016). Attending to these, we can infer that the probable explanation for the results present in our study is the lower knowledge of participants of their L2.

It is worth mention here studies on morphological processing with low proficient bilinguals which used a simple lexical decision with the paradigm of masked priming. These studies showed that while this kind of bilinguals are not as sensitive to morphological information of words, they seem to be sensitive to morphological information of pseudowords. Li et al. (2017, Experiment 2) applied the mentioned paradigm to English native speakers, as well to high and low Chinese-English proficient bilinguals with two different conditions for pseudowords: suffixed nonwords (i.e., combination of a real word and a real suffix; e.g., *animalful*) and control nonwords (i.e., combination of a real word and a suffix, altering only one letter of the suffix; e.g., *animalfil*). A list of real English words was also included in the lexical decision task as distractors. Through this procedure, the authors observed significant effect for slower responses for native speakers and for high proficient bilinguals, but all there was no difference among the three group of participants for the accuracy data, i.e., all participants demonstrated equally difficulties to reject words with an existing suffix. Similar results were seen in Casalis, Commissaire and Duncan's (2014) study. Taking this in account, we can assume that despite some investigations have demonstrated that non-native speakers not proficient in L2 are not sensitive to morphological information present in words, as seen in our study, as well in the previous ones of Deng et al. (2016) and Li et al. (2017), studies involving the morphological processing of pseudowords seem to show that this group of participants are in part sensitive to these kind of lexical information.

Despite the lower proficiency of L2 may be the probable cause for the results observed, we should also take in consideration some limitations present in the current study. First, no data was collected from a control group of English native speakers in order to ensure that the stimuli used were not the reason for the current outcomes. Specially, since removing the cognates words, which are related to higher priming effects (particularly cognate suffixes), as seen in Comesaña et al.'s (2018) investigation. Second, the experience had a duration of 2 hours, which may be tiresome and could have affect the participants performance in the last tasks. And finally, as the experience was already long, we weren't able to access the performance of participants in the different linguistic profile measures in their native language, which would be important to determine if their lower scores in the different tests were due to their lower proficiency of L2, or it was really linked to a linguistic profile characteristic (e.g. better in vocabulary vs better in spelling).

Future research should try to address the problems above mentioned. In other words, they should procure apply a similar procedure of the one described in this investigation to native as well to non-native speakers, being relevant to divide the latter group of participants according to their level of proficiency of L2, once studies (e.g. Deng et al., 2016; Li et al., 2017) have shown that this variable affects the performance of bilinguals in a masked priming lexical decision task. It would be also pertinent to increase the sample of participants, once despite not finding significant results, the pattern expected was present (higher priming effect for transparent condition, intermediate priming effect for opaque condition and smaller priming effect for orthographic control condition). Another variable that should be also taken in account is the evaluation of the linguistic profile characteristic in L1 and L2.

In conclusion, the results of this study seem to support Ullman's theory (2002) that bilinguals not proficient in L2, contrary to native speakers, are not able to process derived complex words automatically.

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